# Accelerator Preparations for Future Fixed Target Experiments at Fermilab

***Tevatron Stretcher Ring***

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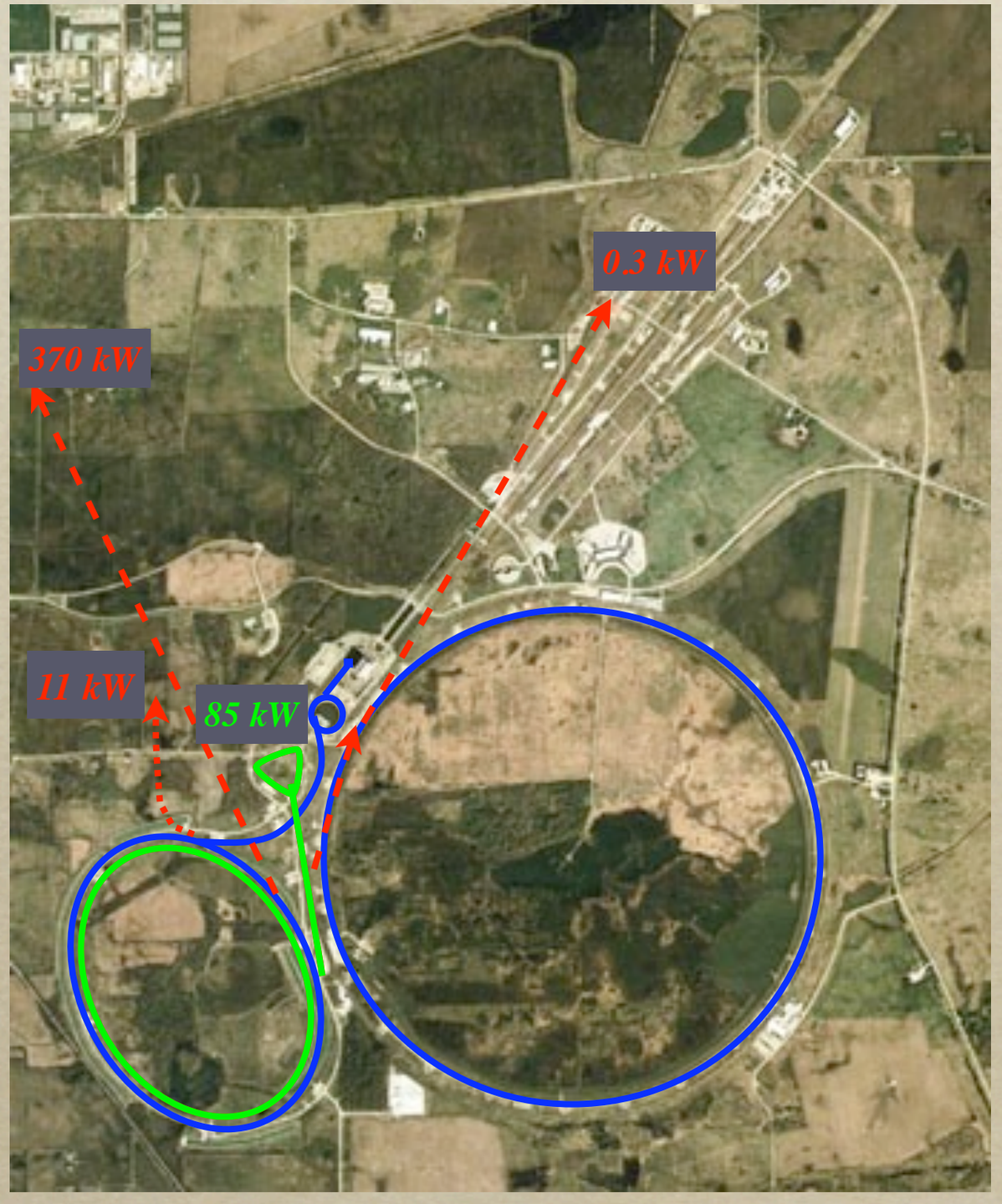
*Fermilab*

- *"Discussion of Tevatron Fixed Target Options after Run II," Fermilab Beams-doc-2849*
- *"Tev120 -- Life after Run II?," Fermilab Beams-doc-2222*
- *Proposal P996 -- Measurement of the $K^+ \rightarrow \pi^+ \nu\bar{\nu}$ Decay at Fermilab*
  - *http://www.fnal.gov/directorate/program_planning/Nov2009PACPublic/kpnn_proposal_final.pdf*

# Run II Proton Availability

- *Daily Operation*
  - *Set up p-pbar store in Tevatron, ...*
  - *Produce more antiprotons, and drive the **neutrino** program*
    - *time line governed by 15 Hz Booster operation*
  - *11 Booster pulses to MI every 2.2 s*
    - *9 for NuMI*
    - *2 for pbar production*
  - *Off-load pbars to Recycler ~every hour*
  - *Spare BOO pulses (~4) to miniBooNE*
  - *1 MI pulse to SY120 occasionally...*

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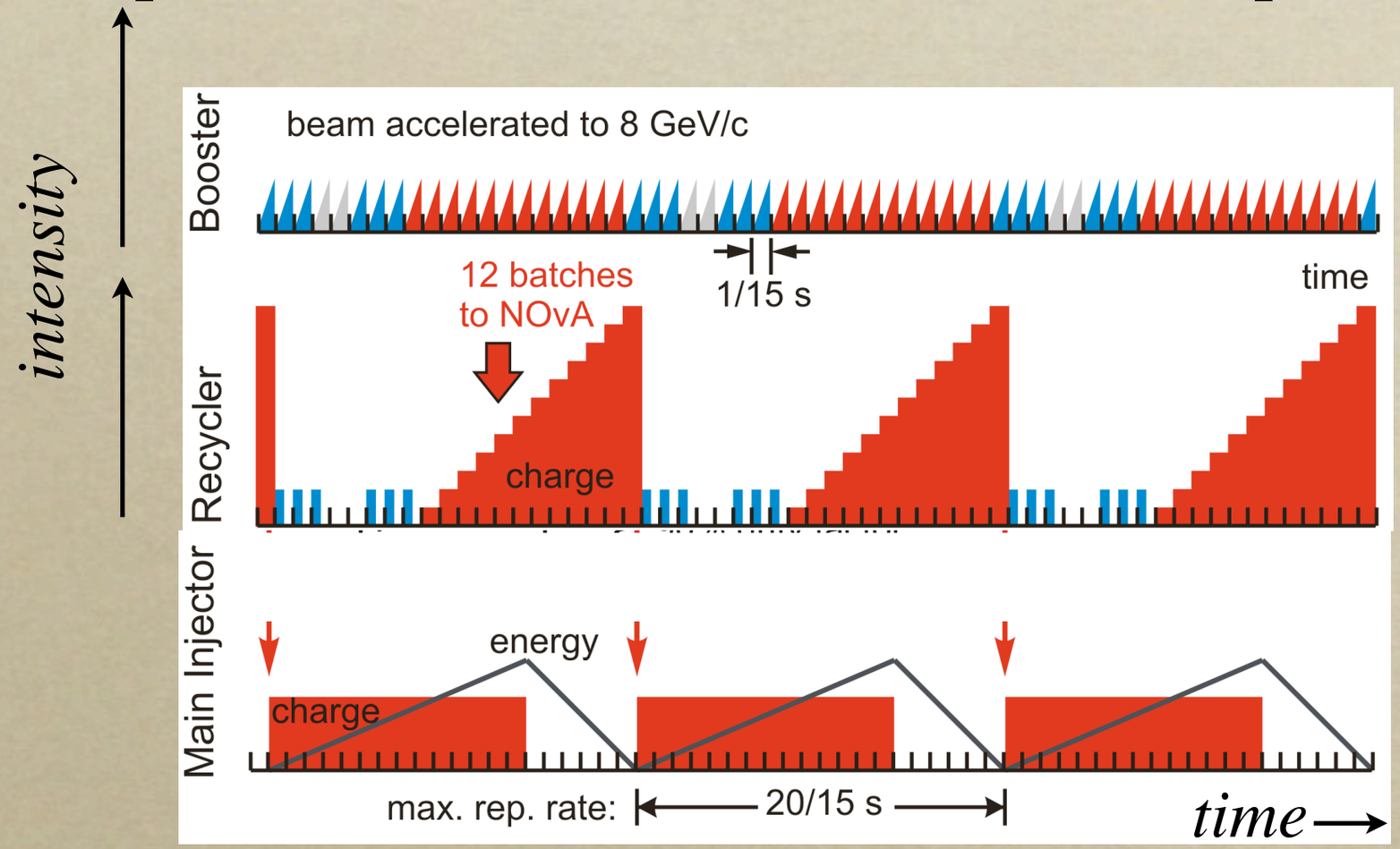
# The Tevatron Stretcher

- *With the Tevatron Collider Run II complete, the possibility will exist to use the Tevatron as a "stretcher" ring to provide high intensity, high duty factor beams to fixed target experiments*
  - *SY120/150 -- the existing SY120 program could be fed from the Tev, perhaps upgraded to 150 GeV*
  - *Kaons Redux -- Proposal P996 has been submitted for $K^+ \rightarrow \pi^+ \nu \nu_{bar}$ search using Stretcher concept*

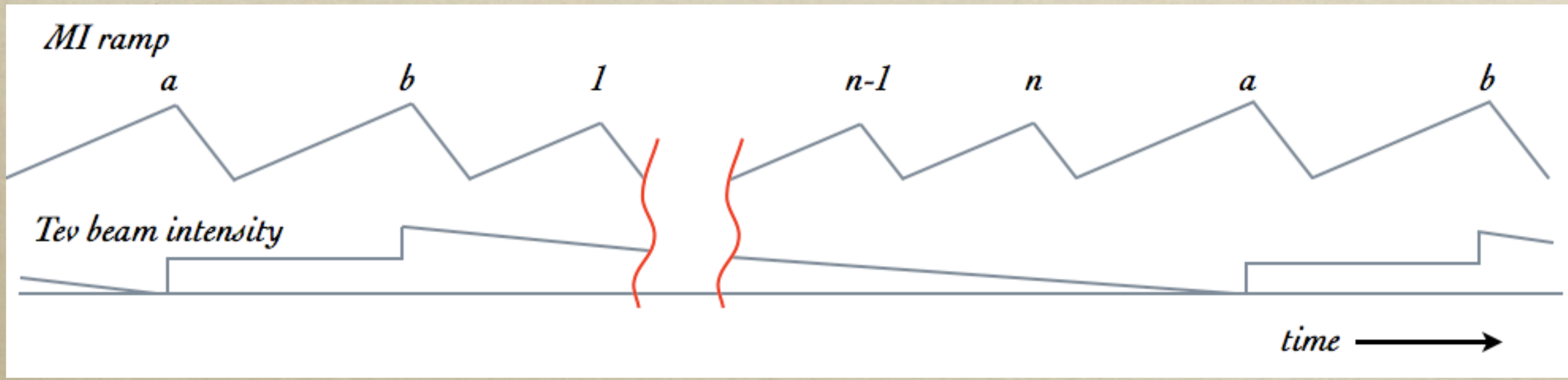
# NuMI/NOvA, after Run II

- *Following Run II, the Main Injector will accept up to 12 Booster pulses to be sent to the* NOvA *experiment*



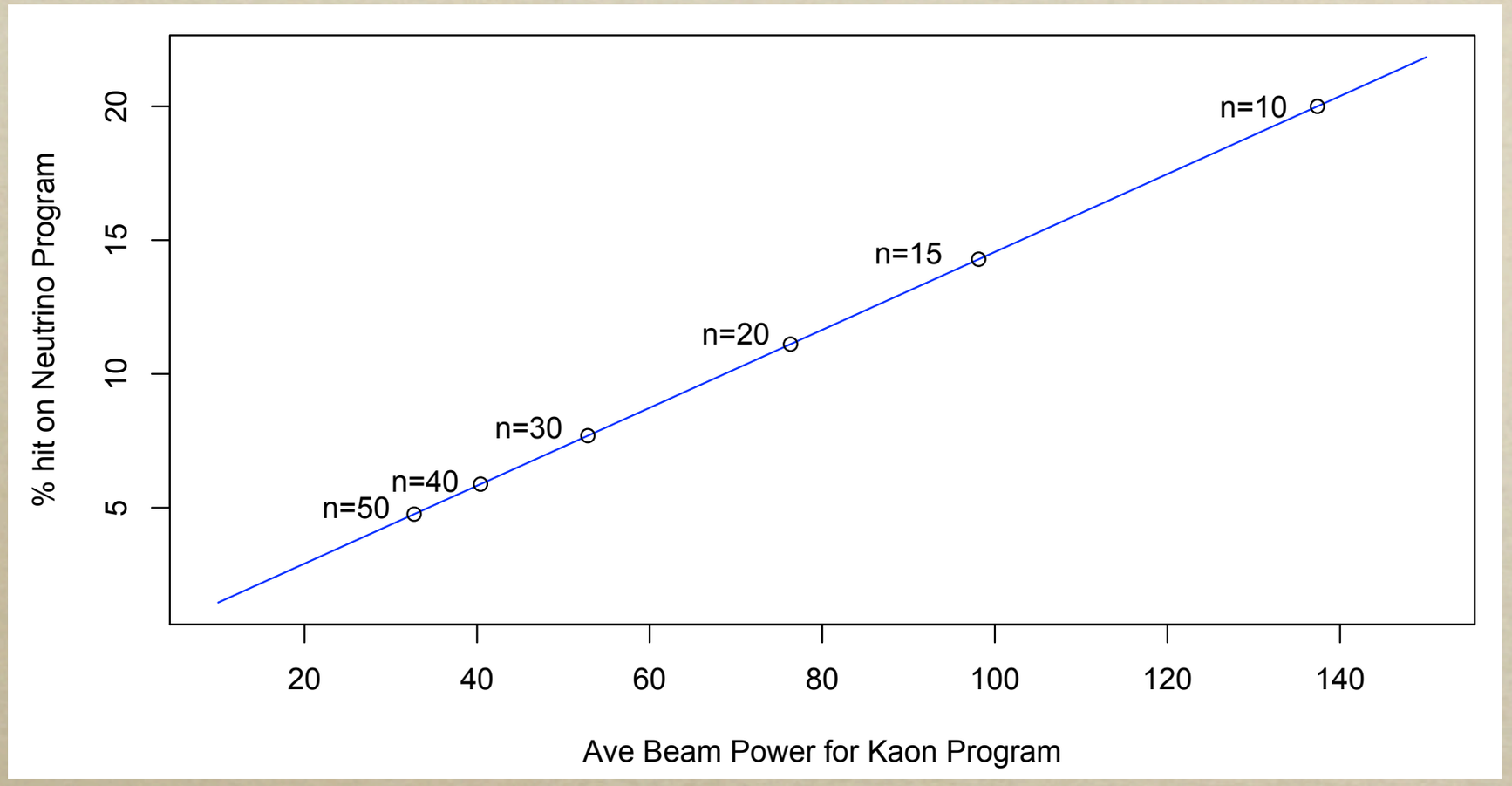

- *20 15-Hz Booster cycles (1.333 sec) per NOvA cycle*

# Tevatron Stretcher




- *As circumference of Tevatron is twice that of Main Injector, take two MI pulses to fill the Tevatron, followed by n pulses to NOvA*
- *Slow spill over the next n+1 MI cycles to fixed target experiments from the Tevatron*

# NOvA Impact




- *Can have respectable, high duty factor beam with ~10% hit to NOvA*
- *Can use to feed MTest as well, with no further impact on NOvA*

| $T_0$[s] | df[%] | hit[%] | $P_{ave}$[kW] | $P_{max}$[kW] | $\dot{N}_{max}$[Tp/s] |
|---|---|---|---|---|---|
| 16.67 | 90 | 20 | 137 | 153 | 6 |
| 23.33 | 93 | 14 | 98 | 106 | 4 |
| 30.00 | 94 | 11 | 76 | 81 | 3 |
| 43.33 | 96 | 8 | 53 | 55 | 2 |
| 56.67 | 97 | 6 | 40 | 42 | 2 |
| 70.00 | 98 | 5 | 33 | 34 | 1 |

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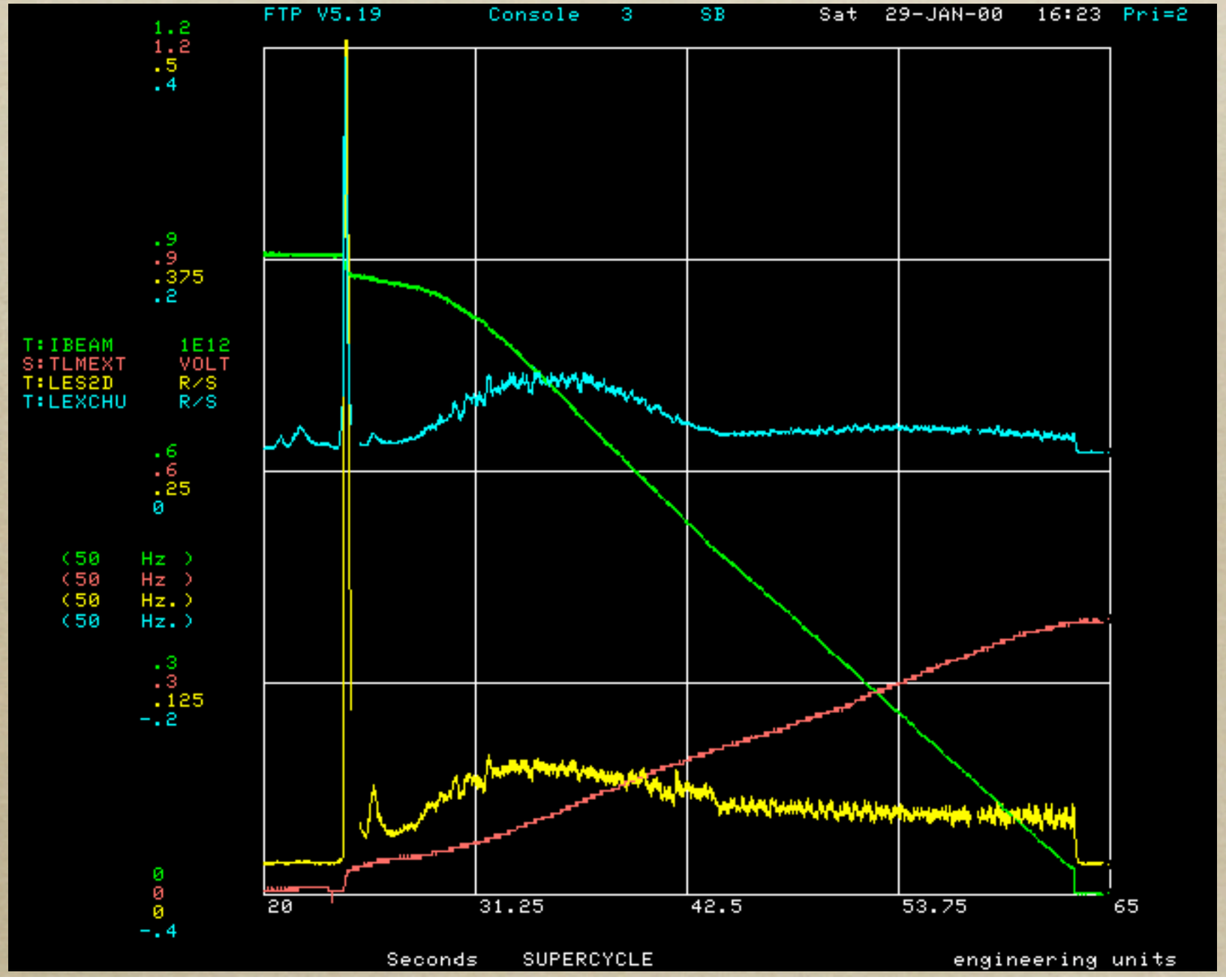
# Has Been Demonstrated

- *Well, sort of ...*
- *KAMI had a short run at the end of the final Tevatron Fixed Target run -- the last beam resonantly extracted from the Tevatron! (Jan 2000)*
- *Performed at 150 GeV with very low intensity*
  - *(~1 Tp/spill over 30 s)*



# Comments, Considerations

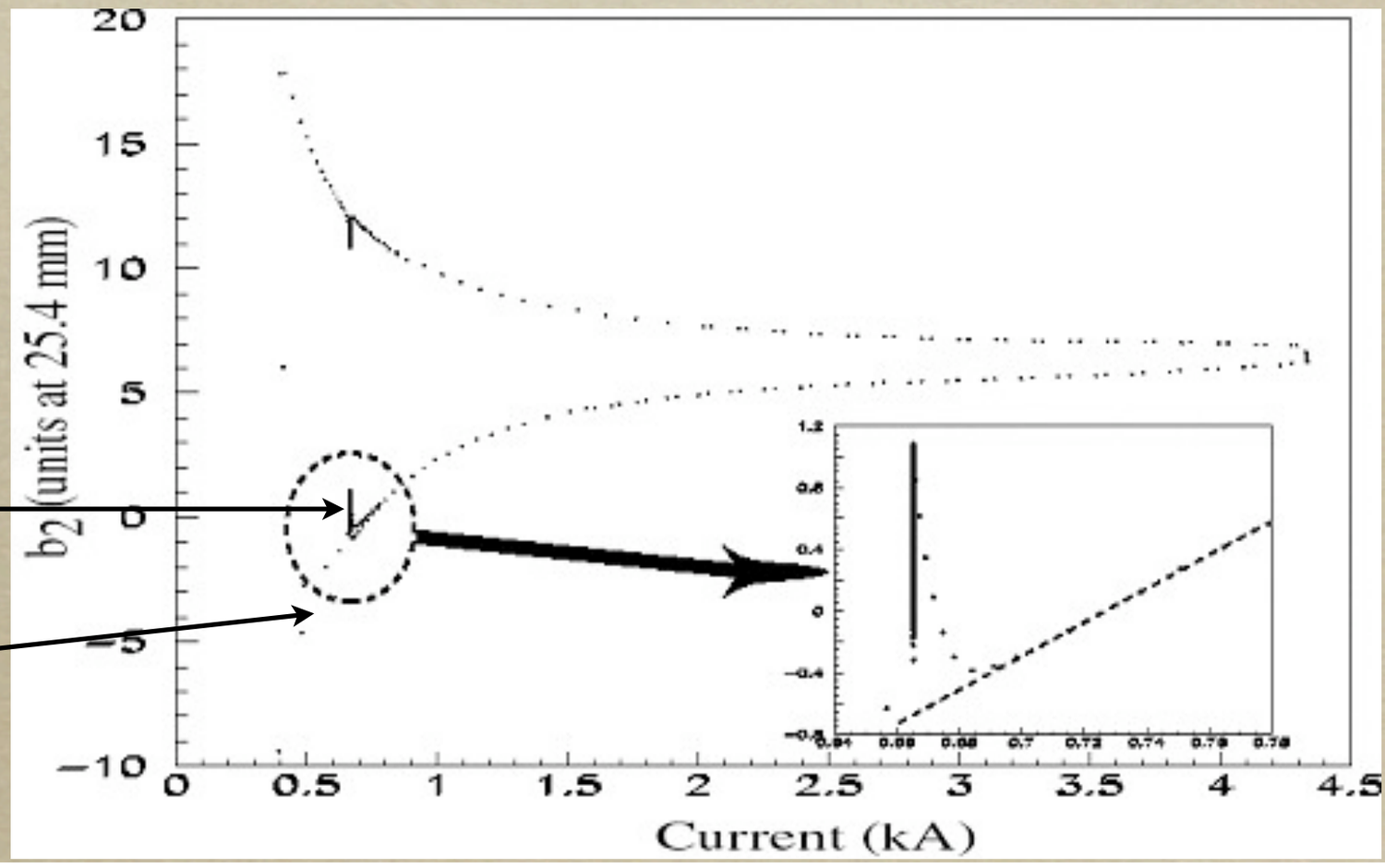
1. *May be able to use existing A0 proton abort system in this scenario.*
   - *100 Tp @ 150 GeV ~ 15 Tp @ 1000 GeV*
2. *Improvements made to impedances and to damper systems during Run II would help with possible beam intensity-related instabilities.*
3. *Beam is ~2x larger at 150 GeV than at 800 GeV (for same emittance), so somewhat less aperture available for slow spill process.*
4. *Use barrier bucket scheme to contain beam during injection and slow spill -- no 53 MHz RF necessary (anode supplies reserved for MI/NOvA)*
5. *Reconfigure to 1983 optics in long straight sections. Re-establish QXR system.*

# Other Comments, Considerations -- II

6. *No magnet ramping, low-beta optics removed, and lower magnet current (thus higher operating margin) --> more reliable operation of magnet system.*
7. *If operate at 120 GeV $b_2$ ~ 25% worse than at 150 GeV, would affect chromaticity range, dynamic aperture, etc. However, $b_2$ drifts with time and would eventually reach asymptotic value (toward zero) -- not so bad?*
8. *Note: 8 GeV program not affected whatsoever; Booster batches to fill MI on SY120 cycles are same as on NOvA cycles; same spare Booster cycles still available*

*30 min. drift at 660 A*
*(150 GeV condition)*

*120 GeV = 528 A*

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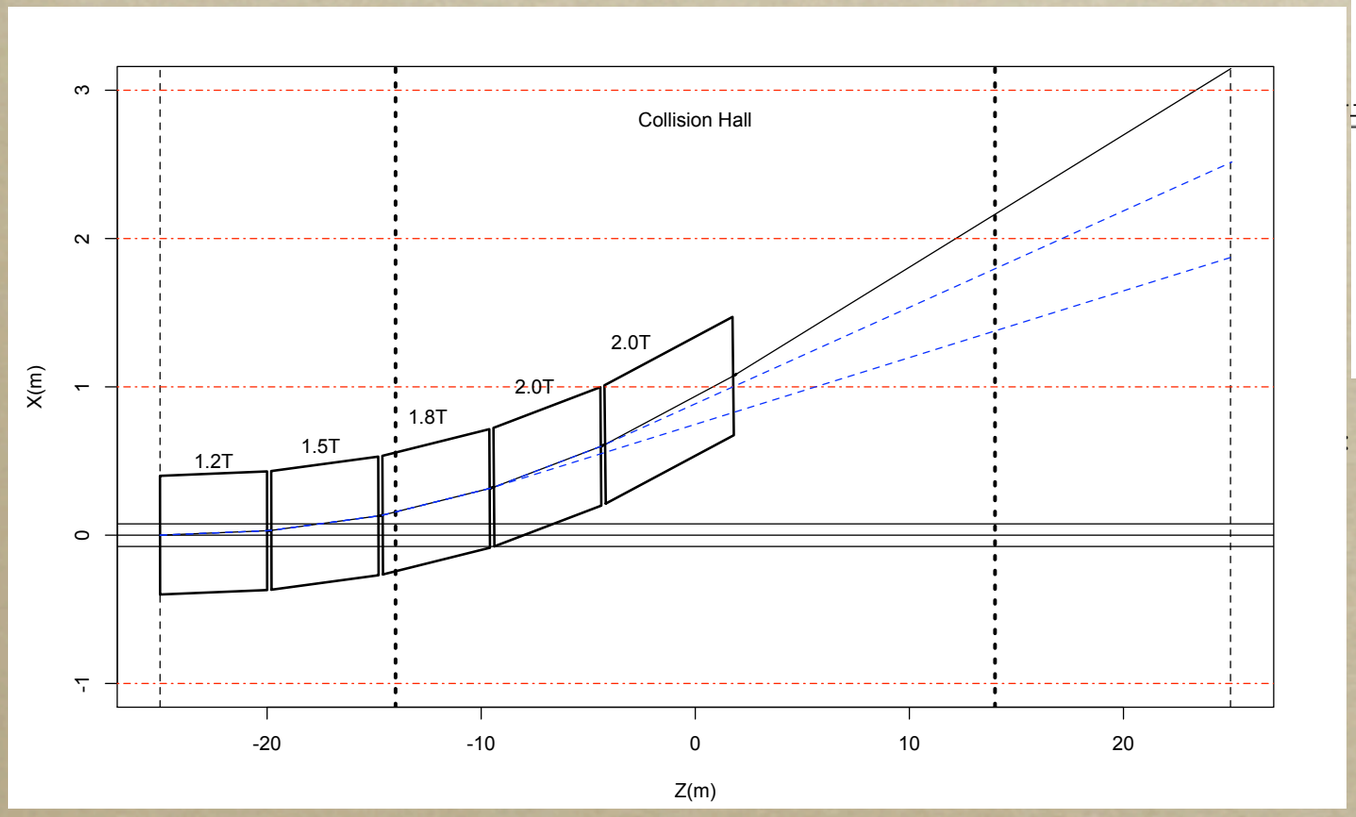
# Tev150 Program

- *With one proposal on the dockets, use of the Tevatron as a Stretcher allows for a fixed target program to develop*
  - *Kaon experiment proposed (P996)*
  - *MTest in operation @ 120 GeV; modify line to 150 GeV*
  - *Opens avenue to future experiments in SY, or in Tev*
- *Kaon proposes using CDF/B0; can explore either...*
  - *multiple extraction points from Tevatron, or*
  - *pulse separate extraction devices, orbit bumps during spill*

# Kaon Experiment at B0

- *Would perform 1/2-int. resonant extraction (vertically) into horizontally bending Lambertson magnets and C-magnets*
- *Well-shielded beam dump in Collision Hall forward region; experiment "fits" within CDF Hall and access area*



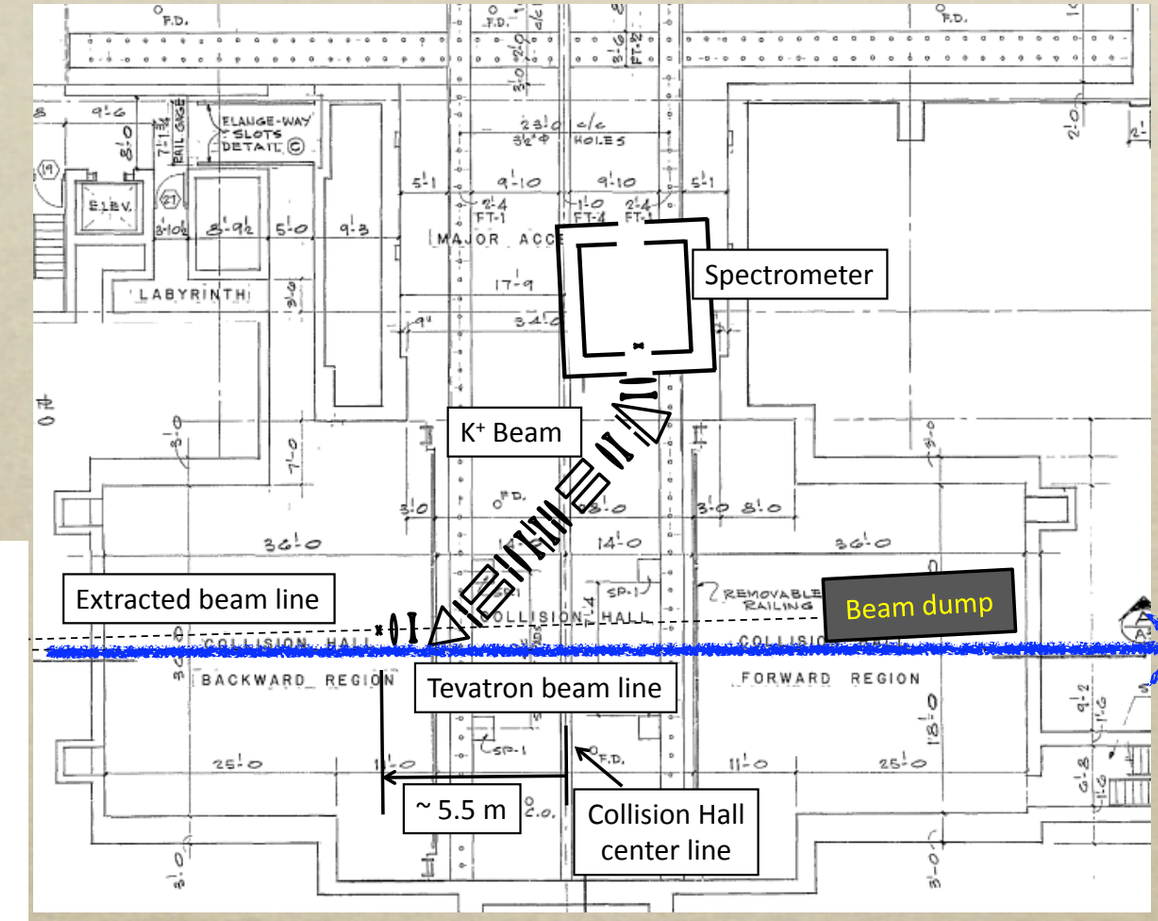




Illustration of the P996 beamline and detector sited within the B0 collision hall.

*(from P996 Proposal)*

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# Choice of Extraction Point

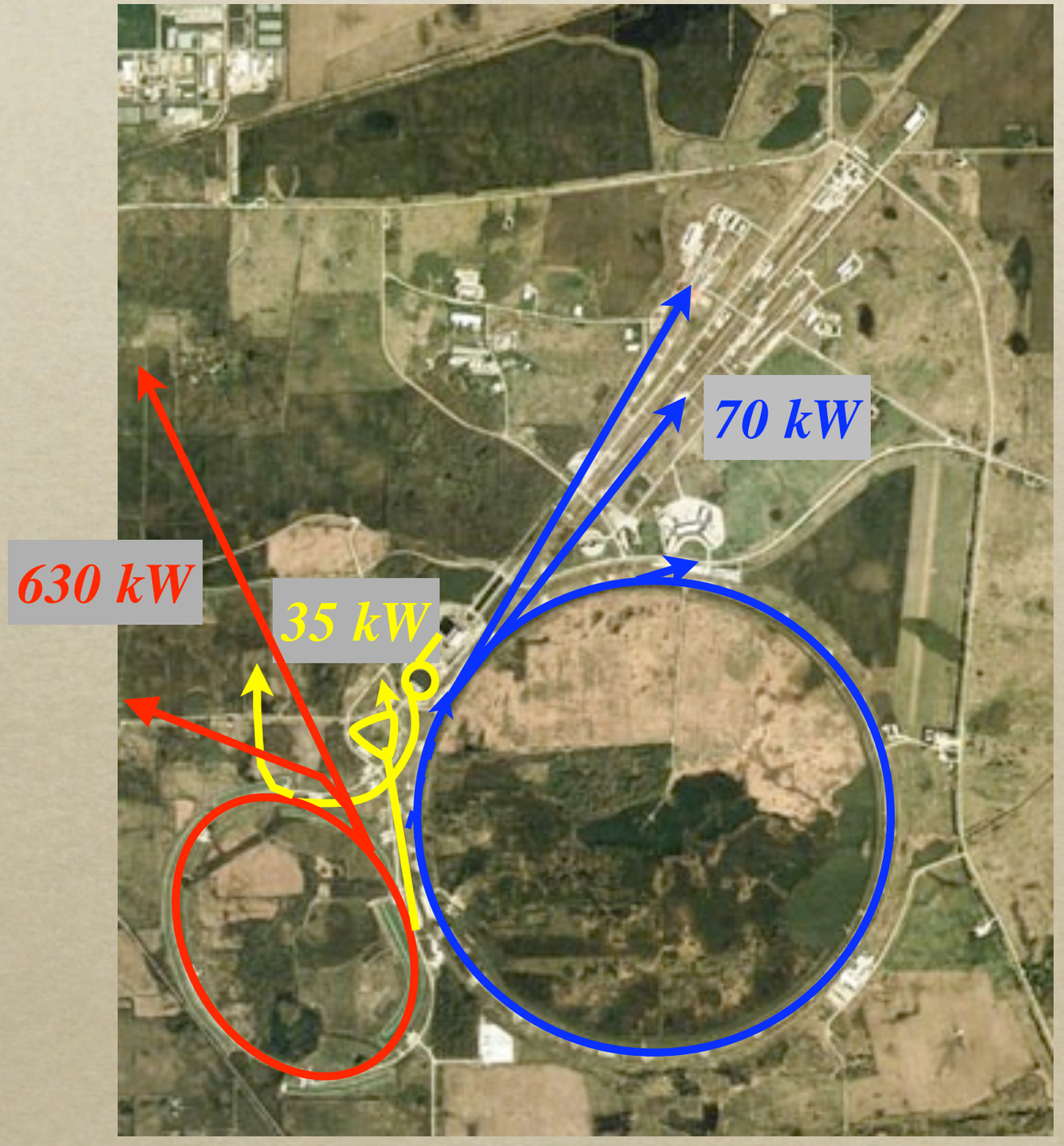
- *A0*
  - *Return to original Fixed Target layout; since at 150 rather than 800 GeV, could perhaps run with fewer elements*
  - *Restore Electrostatic Septa at D0; restore FT optics*
- *B0*
  - *Put electrostatic septa at E0, with high-beta optics at both B0 and E0. May wish special straight section layout at B0 to give more clearance between circulating beam and experiment*
  - *Can re-use A0 Lambertson magnets, rotated? (Need to extract vertically, not horizontally.)*

# Design Studies and Beam Tests

- *What intensity can the Tevatron sustain at 150 GeV?*
- *How clean can slow extraction be at 150 GeV?*
- *Optical design/layout for Tevatron FT operation*
- *Ensure use of the A0 abort system for this scenario*
  - *proton-direction only*
- *Proper placement/re-commissioning of QXR system*
- *Develop RF requirements -- Barrier Bucket system*
- *Analysis of Power (Op.) requirements -- esp. Cryo*
- *Shielding requirements if use B0 as experimental region*

# Proton Fixed Target Programs (*ca.* 2015)

- *Future Daily Operation*
  - *Run **NuMI/LBNE***
  - *Run **microBooNE, g-2, Mu2e, target R&D, EDM, muCool, ...***
  - *Run **MIPP, MTest, Drell-Yan, Kaon, ...***
- *Plus…*
  - *NML/ILCTA (A0)*
  - *Project X*
  - *…*

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